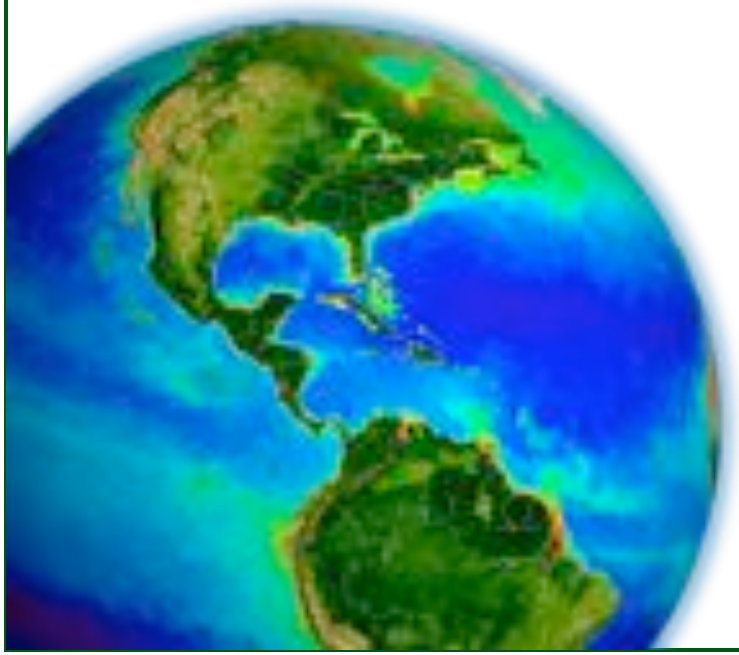
Achieving Consistency in the Multi-Mission Ocean Color Data Record



Bryan Franz

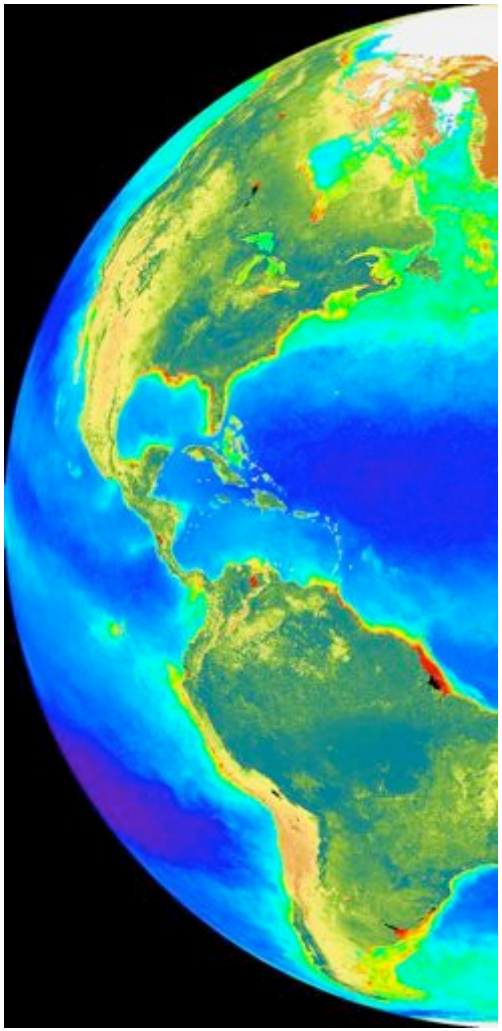
and the

NASA Ocean Biology Processing Group

MODIS Science Team Meeting

19 May 2011 – College Park, MD

Outline



How we define a Climate Data Record

How we achieve CDR quality

Results of latest reprocessing effort

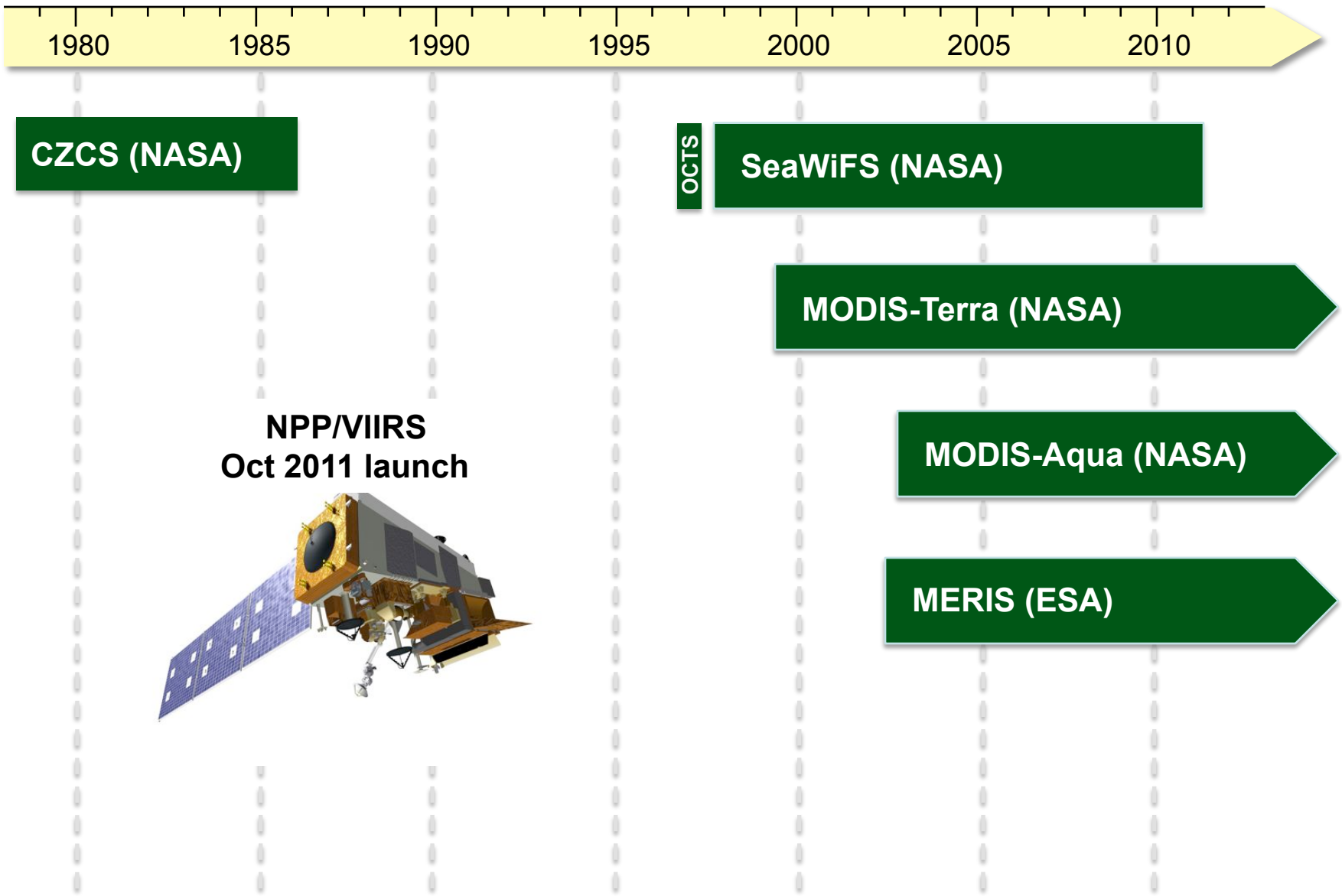
Future directions

What is a Climate Data Record?

"A climate data record is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change."

U.S. National Research Council, 2004

Length & continuity requires multiple missions

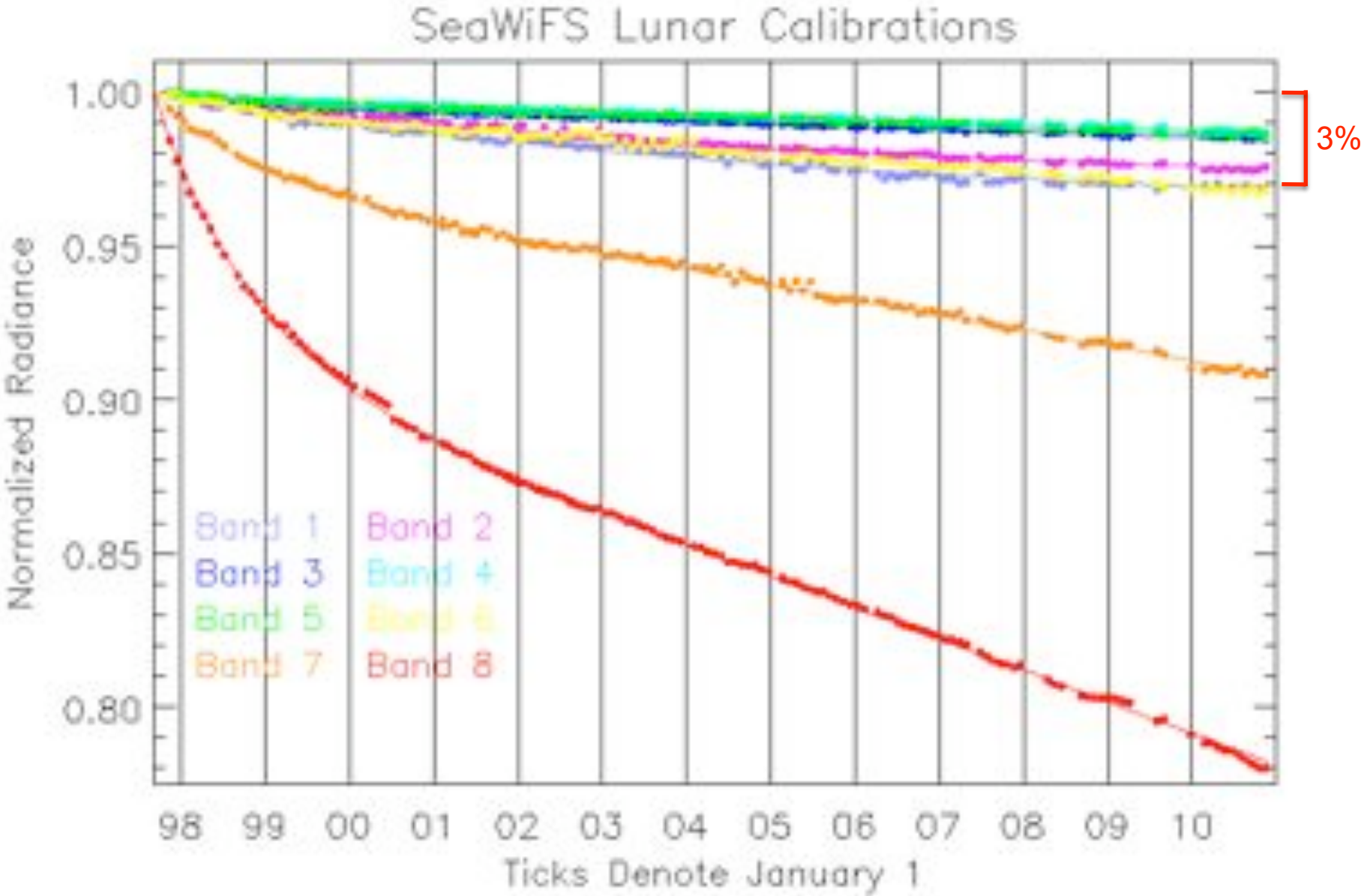


How do we achieve consistency?

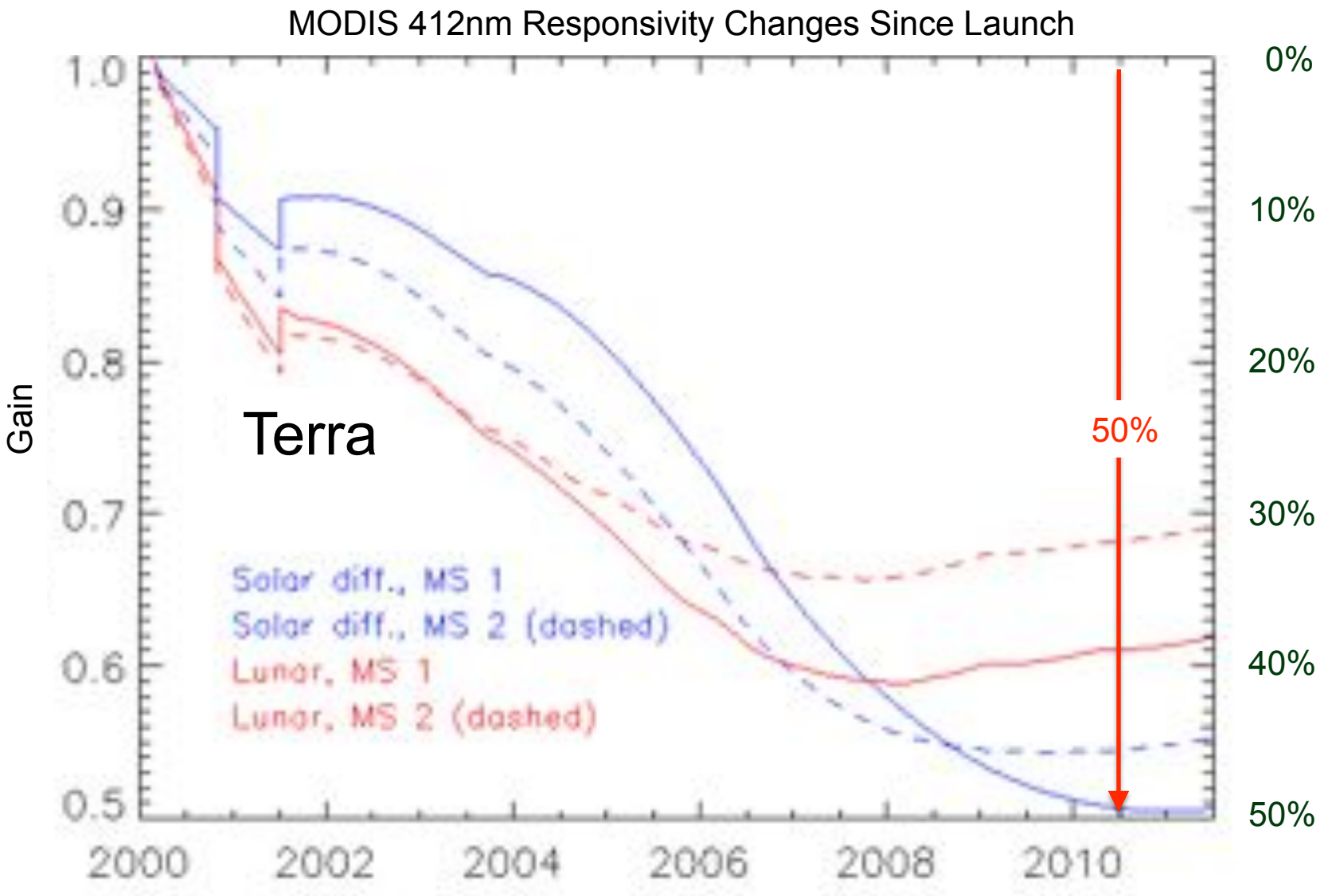
How do we achieve consistency?

- Focus on instrument calibration
  - establishing temporal and spatial stability within each mission

SeaWiFS Sensor Degradation

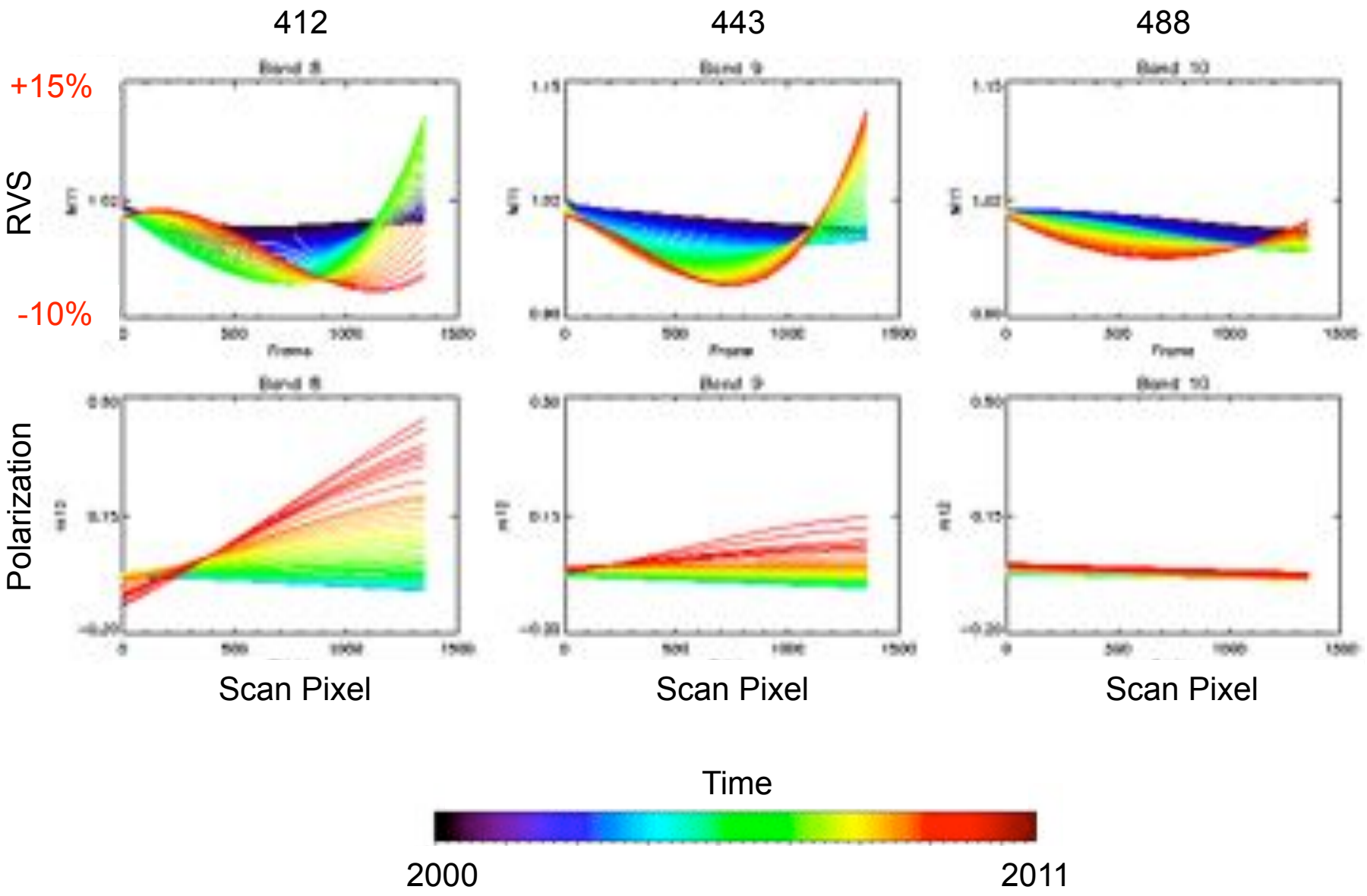


MODIS Lunar and Solar Calibration Trends



MODIS-Terra Vicarious On-orbit Characterization

relative to preliminary MCST collection 6 calibration

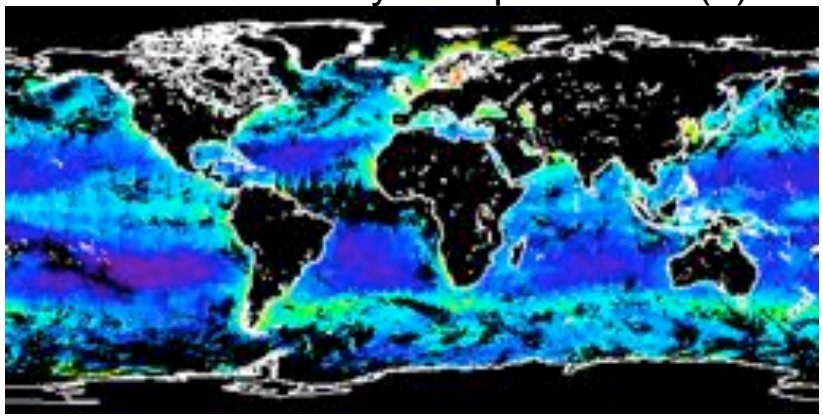


Vicarious Instrument Recharacterization

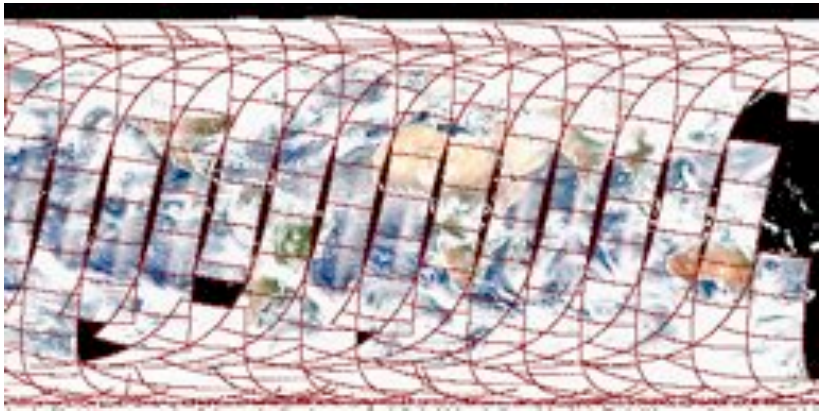
to assess change in RVS shape and polarization sensitivity

$$L_m(\lambda) = \mathbf{M_{11}} L_t(\lambda) + \mathbf{M_{12}} Q_t(\lambda) + \mathbf{M_{13}} U_t(\lambda)$$

SeaWiFS 15-Day Composite nLw(λ)



MODIS Observed TOA Radiances



Vicarious calibration:

given $L_w(\lambda)$ and MODIS geometry, we can predict $L_t(\lambda)$

Global optimization:

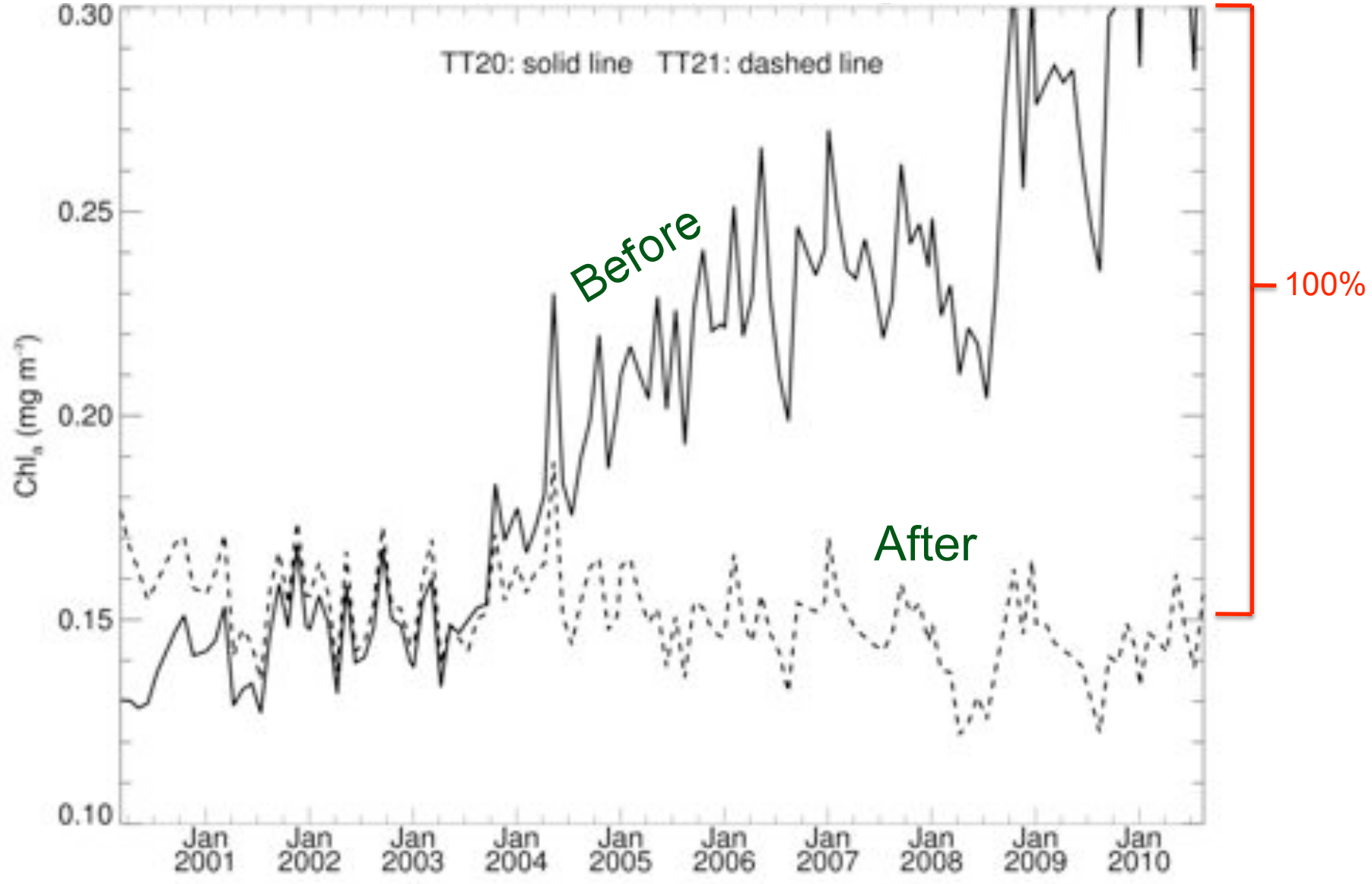
find best fit M_{11}, M_{12}, M_{13} to relate $L_m(\lambda)$ to $L_t(\lambda)$

where M_{xx} = fn(mirror aoi)

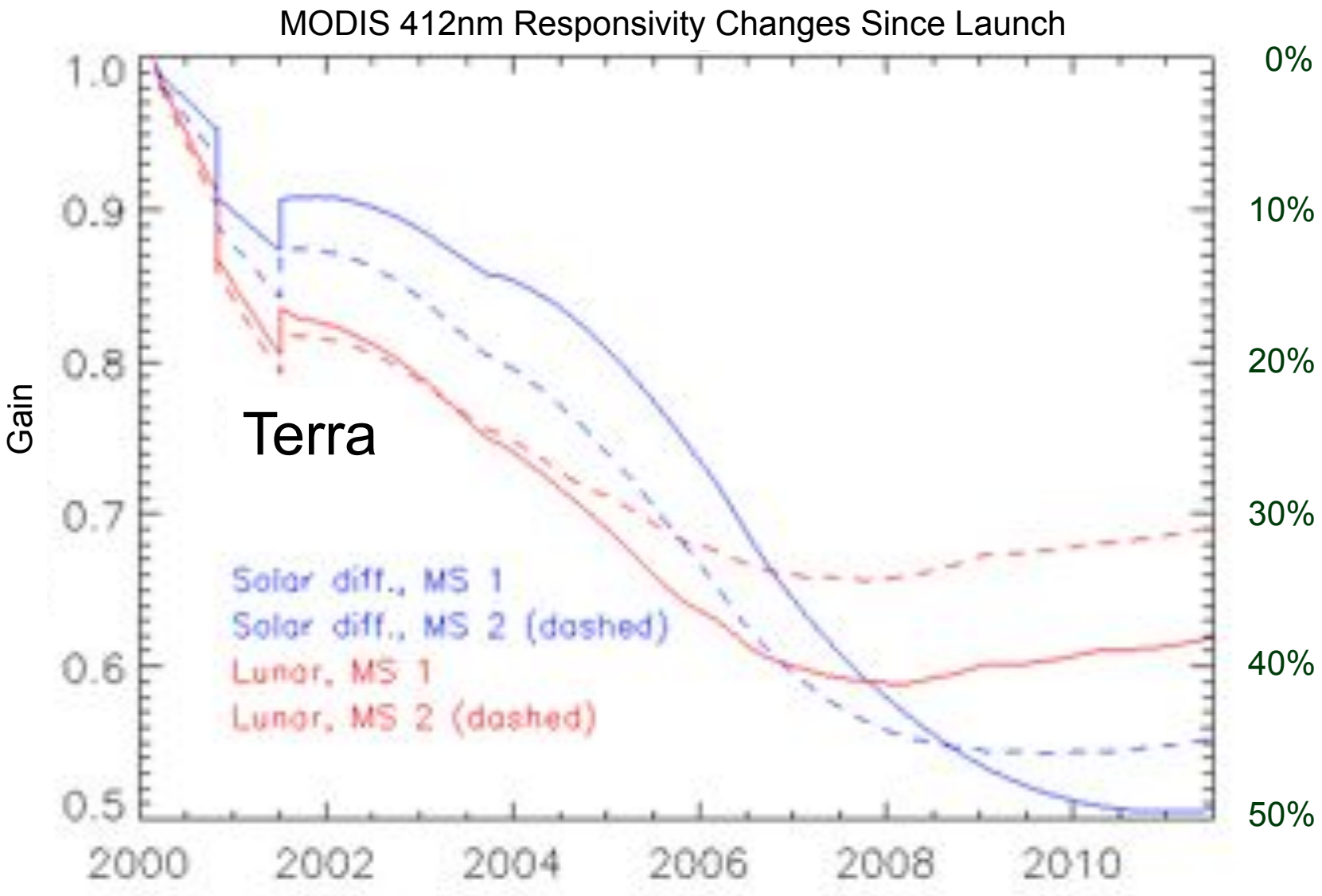
per band, detector, and m-side

Effect of MODIST Recharacterization on Chlorophyll

Global Deep-Water Trend



MODIS Lunar and Solar Calibration Trends



How do we achieve consistency?

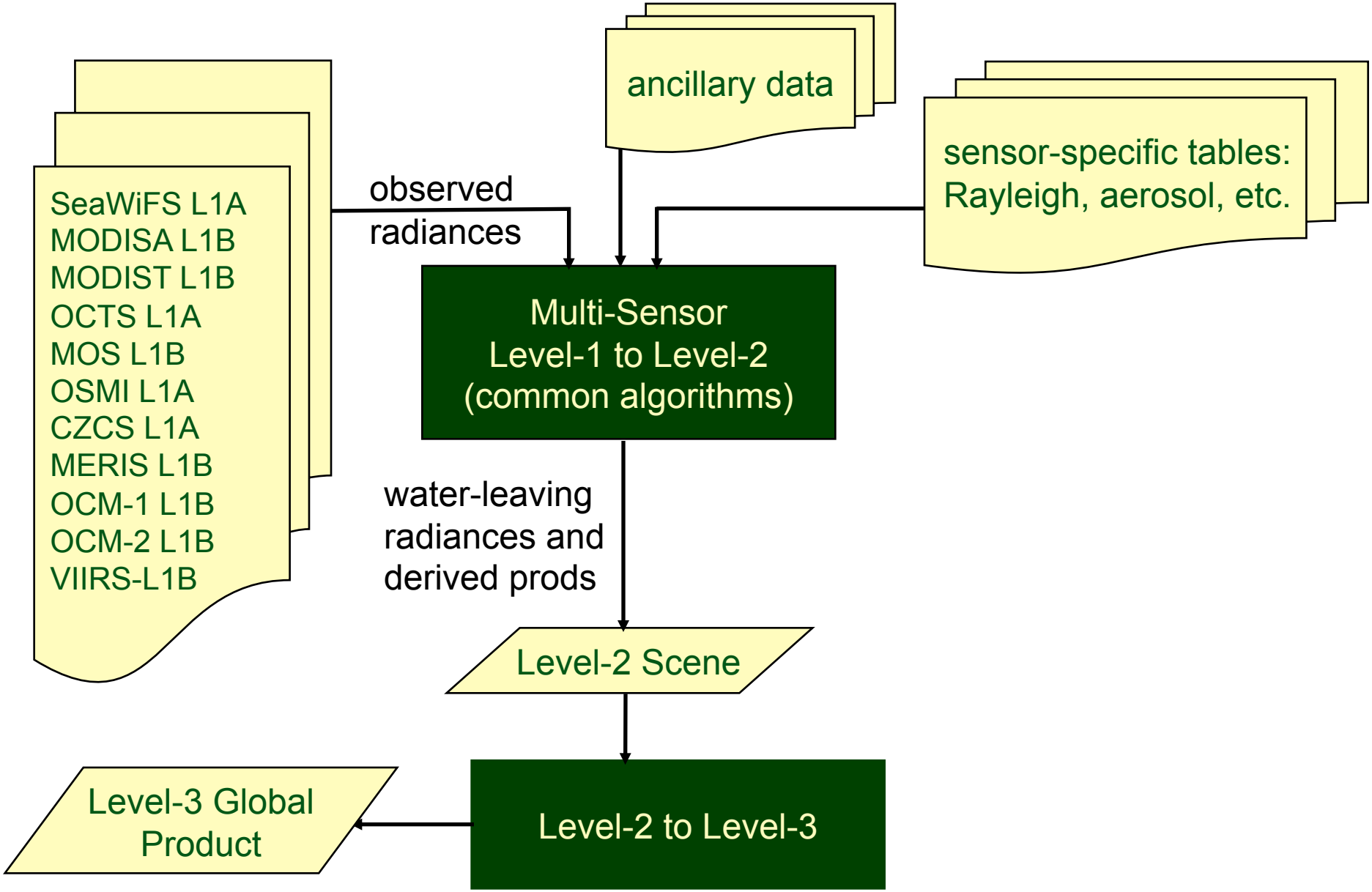
- Focus on instrument calibration
  - establishing temporal and spatial stability within each mission

How do we achieve consistency?

- Focus on instrument calibration
  - establishing temporal and spatial stability within each mission

- Apply common algorithms
  - ensuring consistency of processing across missions

Sensor-Independent Approach



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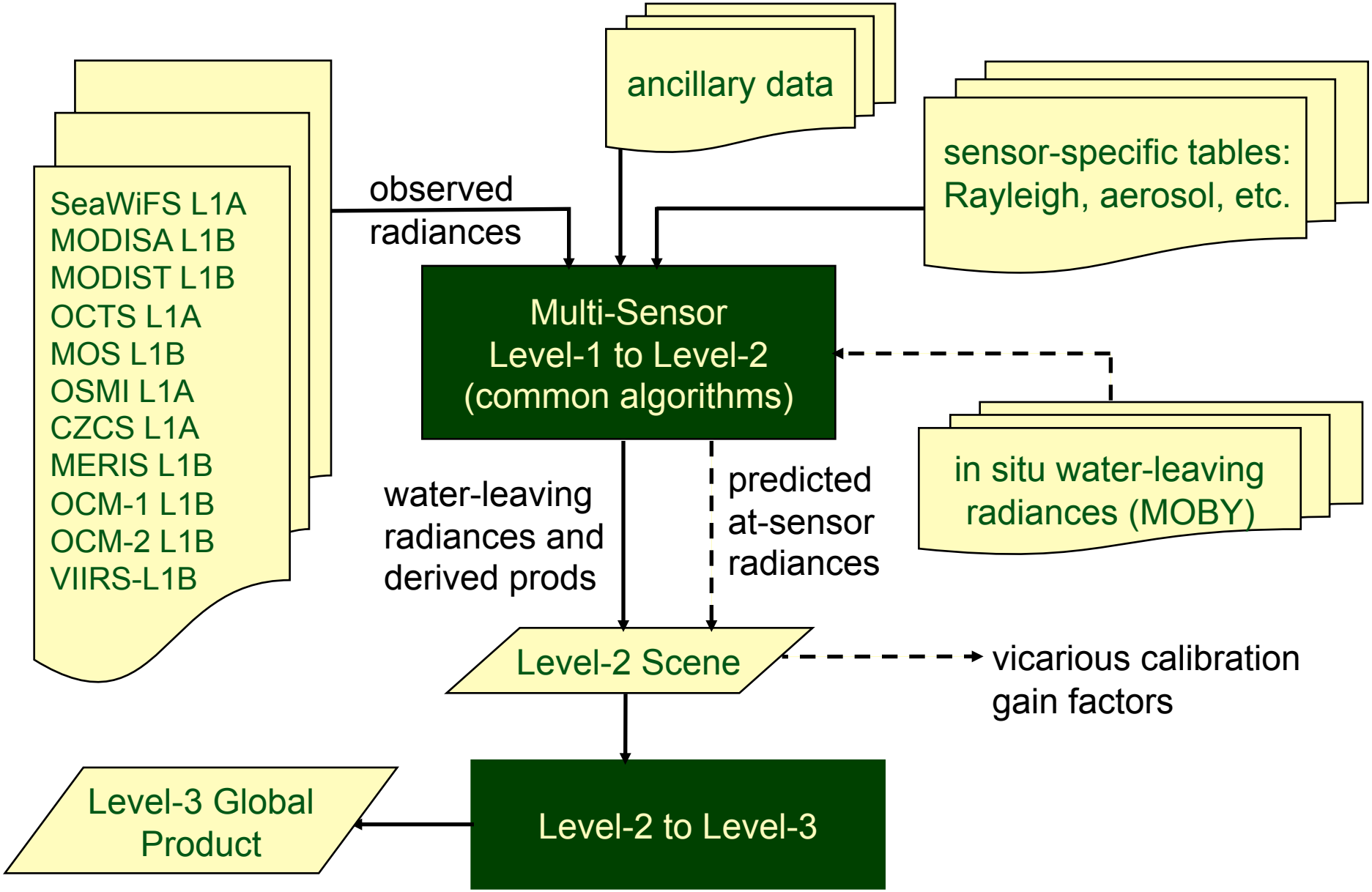
- Apply common vicarious calibration approach
  - ensuring spectral and absolute consistency of water-leaving radiance retrievals under idealized conditions

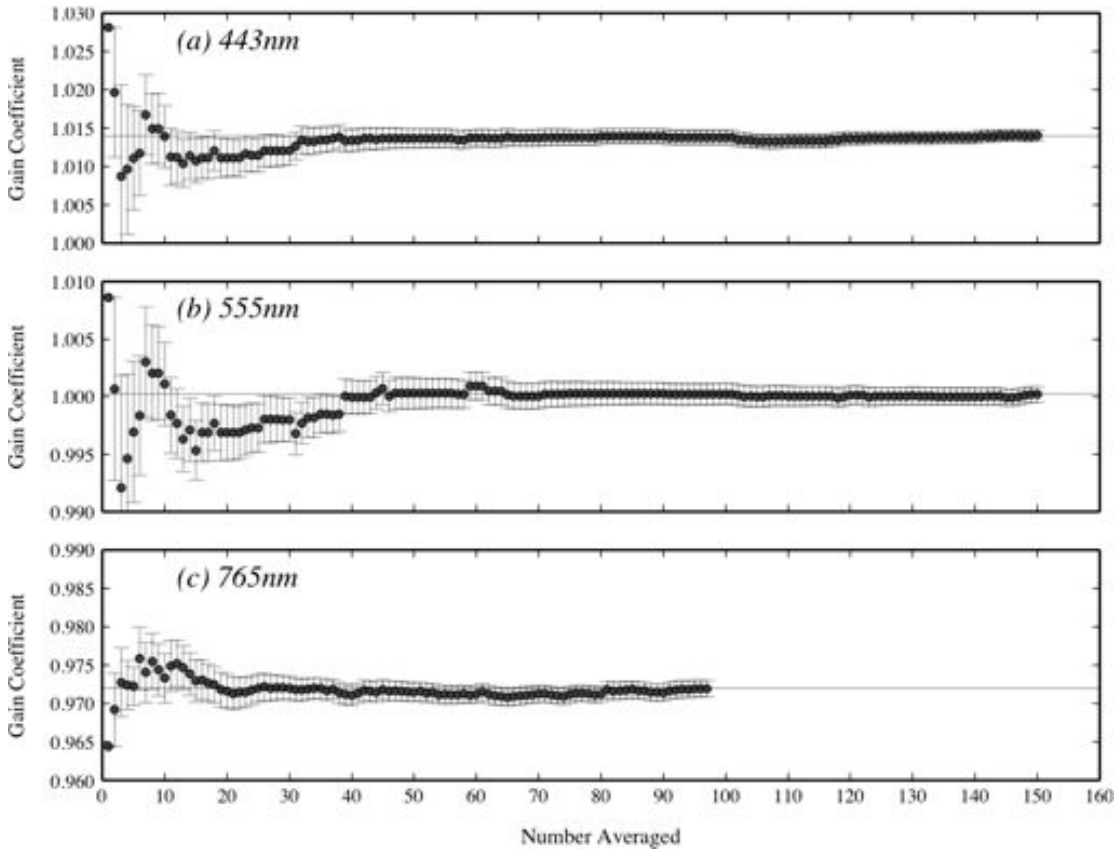
Sensor-Independent Approach



Cumulative mean vicarious gain

It requires many samples to reach a stable vicarious calibration, even in clear (homogeneous) water with a well maintained instrument (MOBY)

SeaWiFS to MOBY



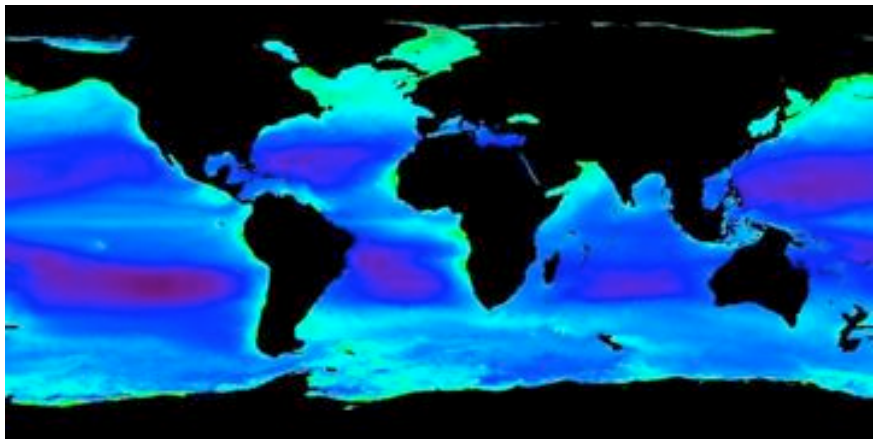
Franz, B.A., S.W. Bailey, P.J. Werdell, and C.R. McClain, F.S. (2007). Sensor-Independent Approach to Vicarious Calibration of Satellite Ocean Color Radiometry, Appl. Opt., 46 (22).

How do we achieve consistency?

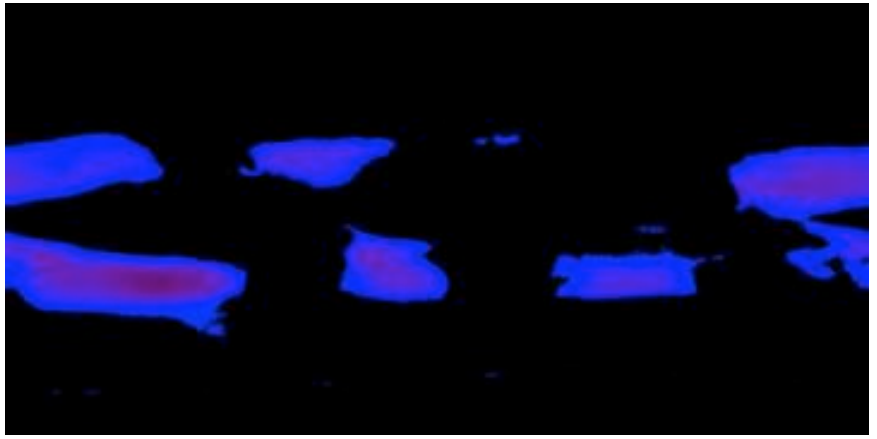
- Focus on instrument calibration
  - establishing temporal stability within each mission
- Apply common algorithms
  - ensuring consistency of processing across missions
- Apply common vicarious calibration approach
  - ensuring spectral and absolute consistency of water-leaving radiance retrievals under idealized conditions
- Perform detailed trend analyses (hypothesis testing)
  - assessing temporal stability & and mission-to-mission consistency

Trophic Subsets

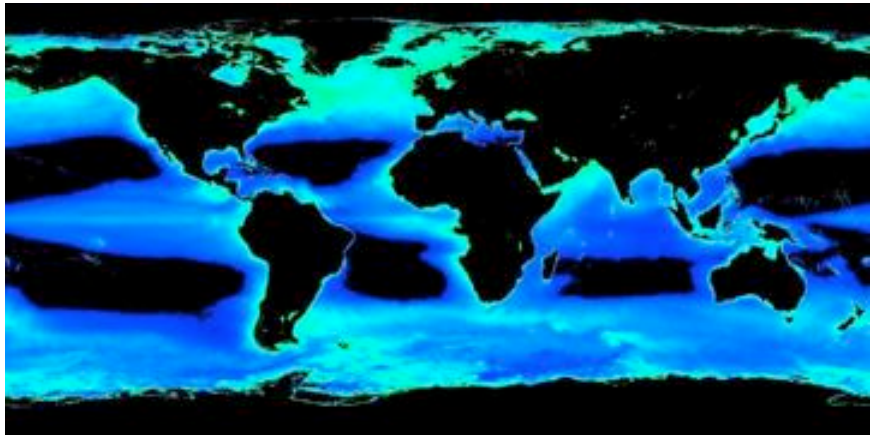
Deep-Water (Depth > 1000m)



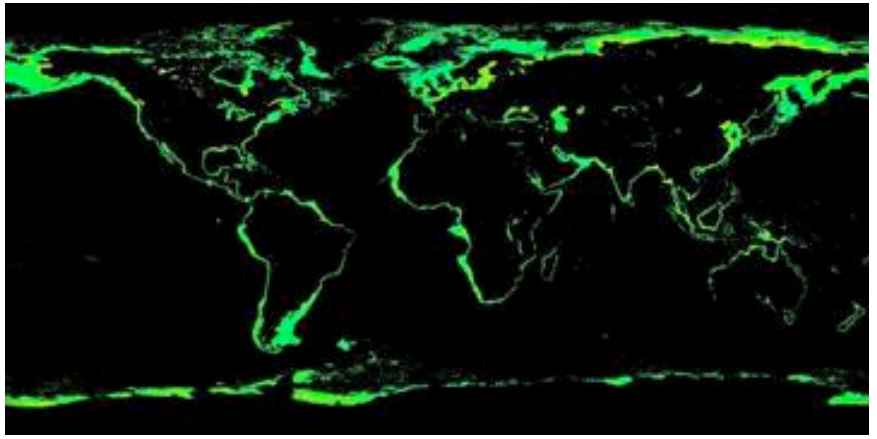
Oligotrophic (Chlorophyll < 0.1 mg m^{-3})



Mesotrophic (0.1 < Chlorophyll < 1)



Eutrophic (1 < Chlorophyll < 10)



How do we achieve consistency?

- Focus on instrument calibration
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- Apply common algorithms
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- Apply common vicarious calibration approach
  - ensuring spectral and absolute consistency of water-leaving radiance retrievals under idealized conditions
- Perform detailed trend analyses (hypothesis testing)
  - assessing temporal stability & and mission-to-mission consistency
- Reprocess multi-mission timeseries
  - incorporating new instrument knowledge and algorithm advancements

Latest Multi-Mission Ocean Color Reprocessing

Scope: MODISA, MODIST, SeaWiFS, OCTS, CZCS

Status:

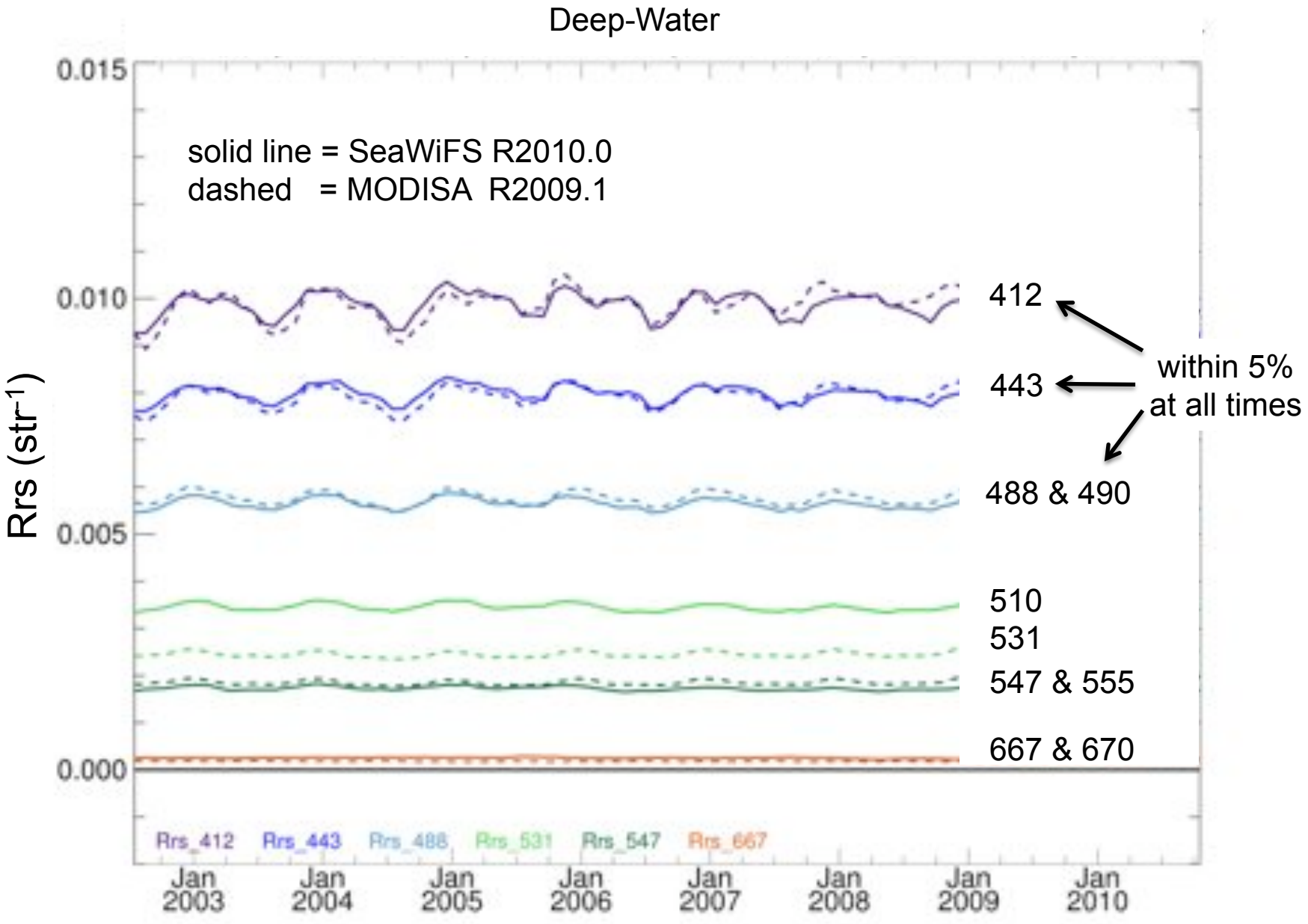
- MODISA completed April 2010 (update in progress)
- SeaWiFS completed September 2010
- OCTS completed September 2010
- MODIST completed January 2011
- CZCS in progress

Highlights:

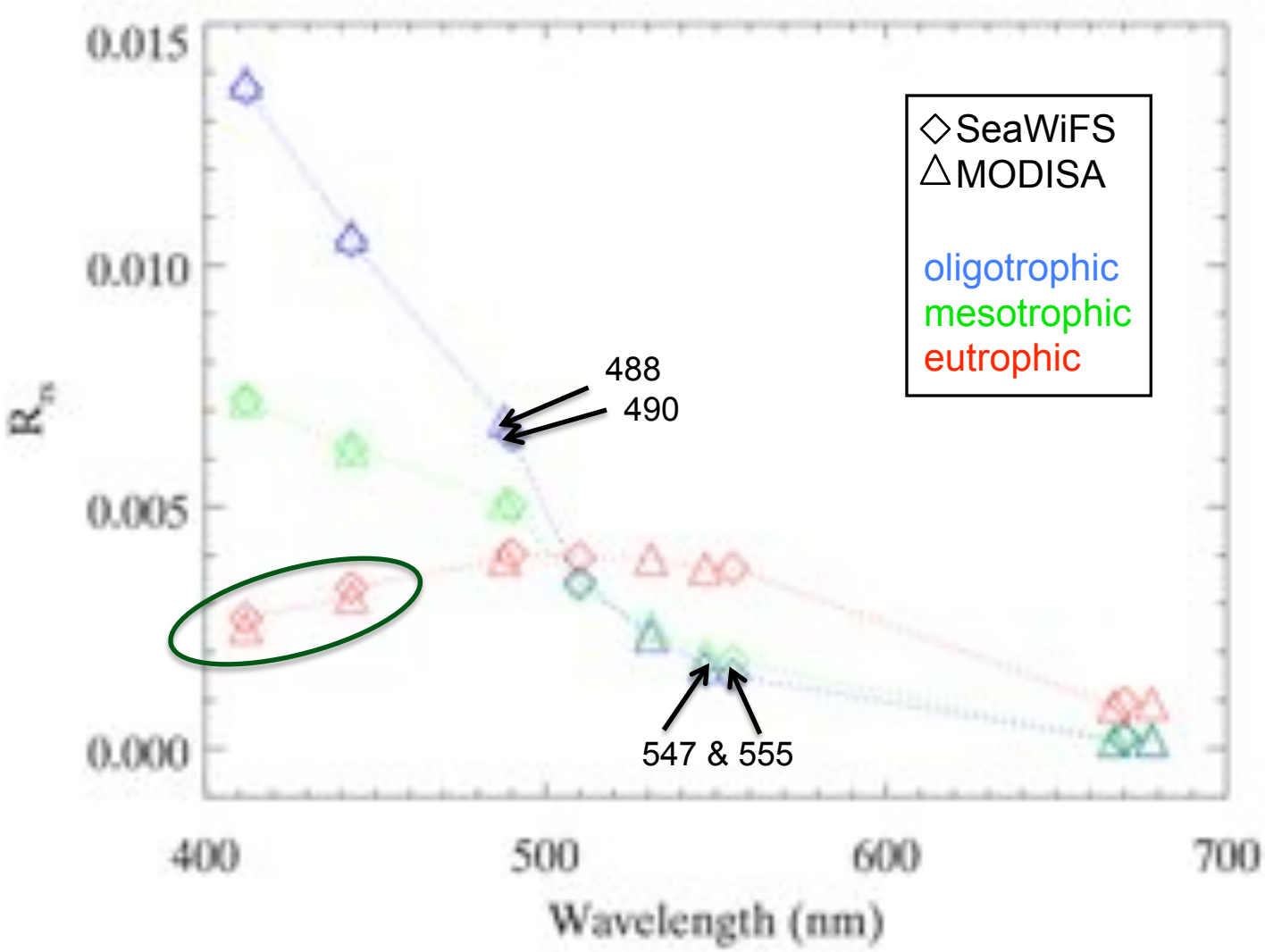
- incorporated sensor calibration updates**
- regenerated all sensor-specific tables and coefficients
- improved aerosol models based on AERONET
- additional correction for NO2
- updated chlorophyll *a* and Kd algorithms based on NOMAD v2

http://oceancolor.gsfc.nasa.gov/WIKI/OCReproc.html

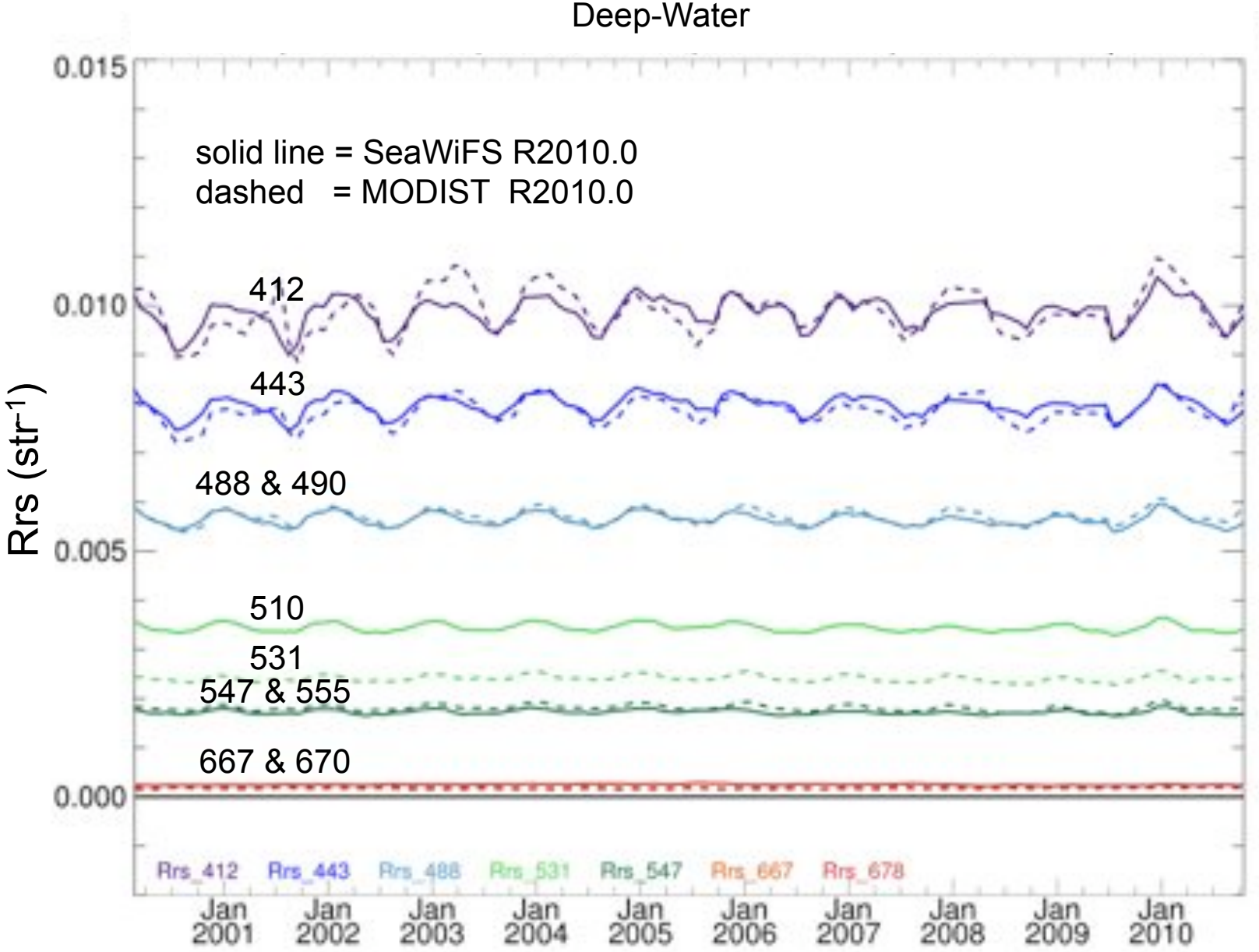
MODISA Rrs in good agreement with SeaWiFS



Mean spectral differences agree with expectations

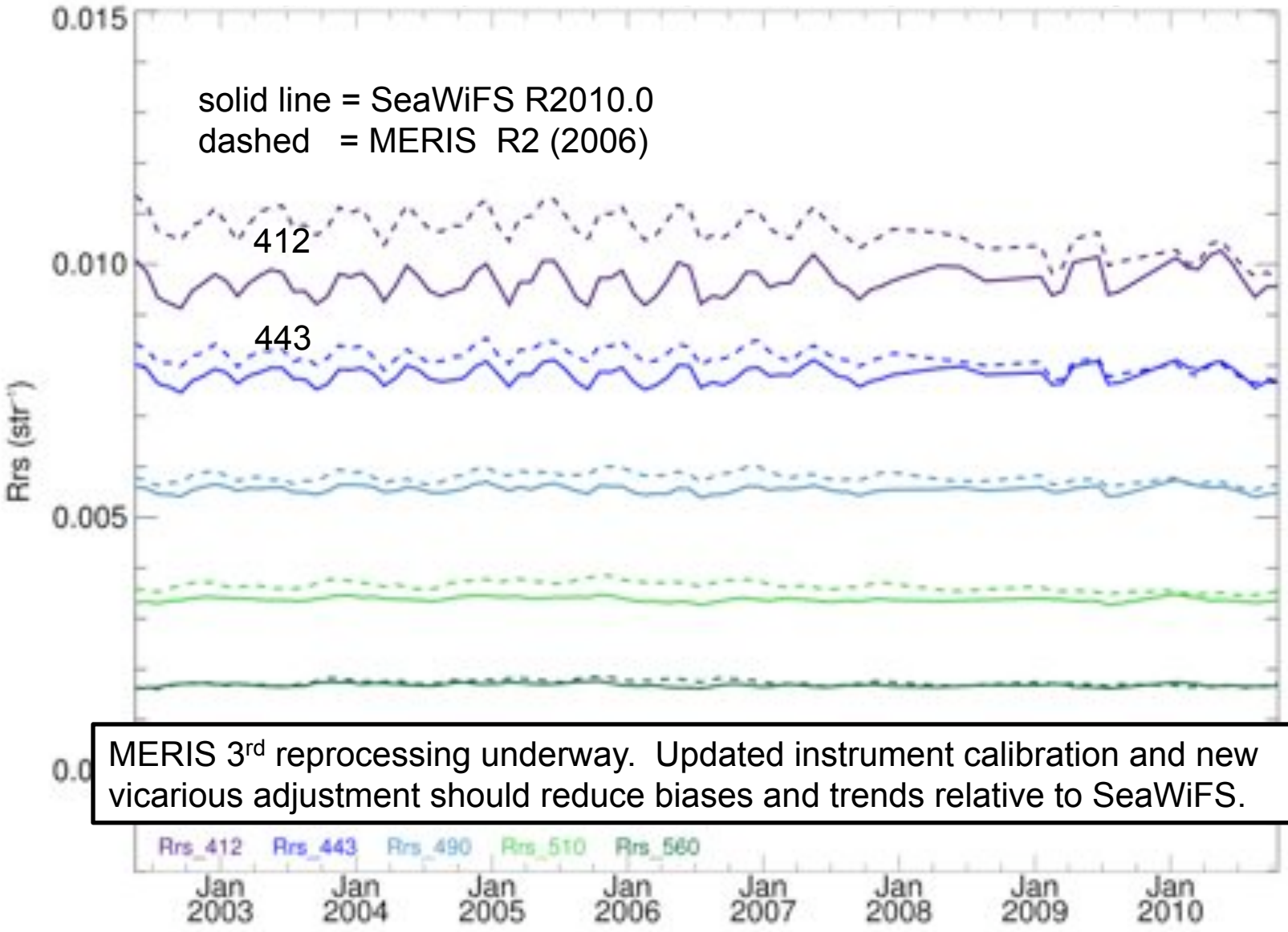


MODIST Rrs in good agreement with SeaWiFS



MERIS Rrs is biased relative to SeaWiFS

Deep-Water

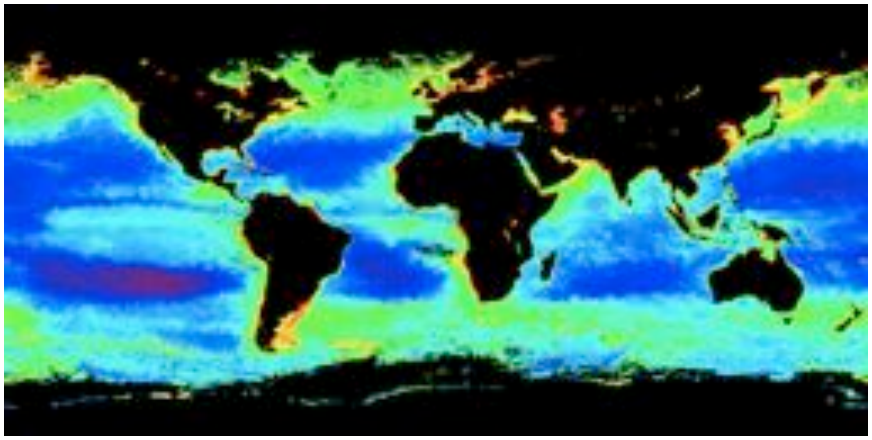


MERIS 3rd reprocessing underway. Updated instrument calibration and new vicarious adjustment should reduce biases and trends relative to SeaWiFS.

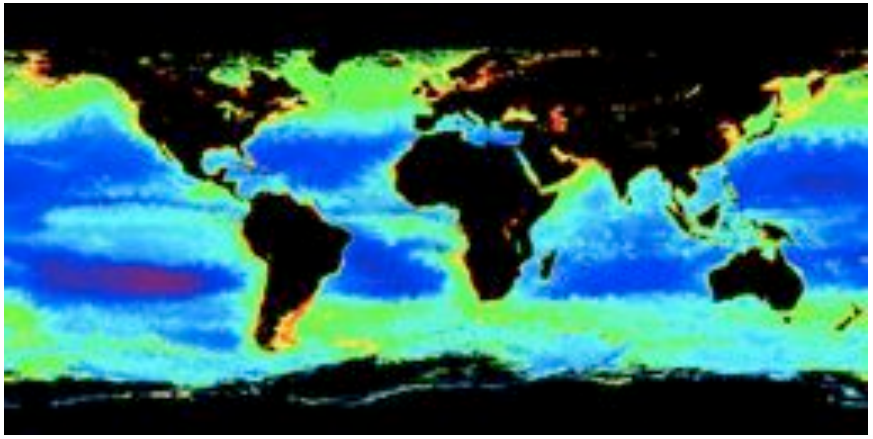
Chlorophyll spatial variation in good agreement

Fall 2002

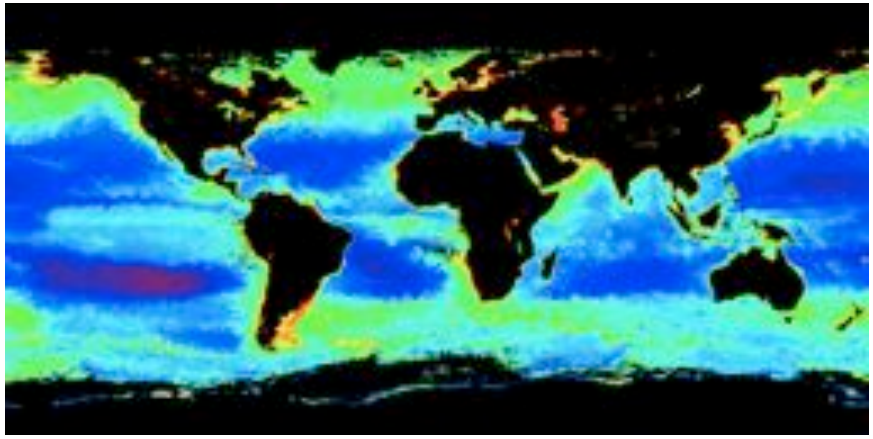
SeaWiFS

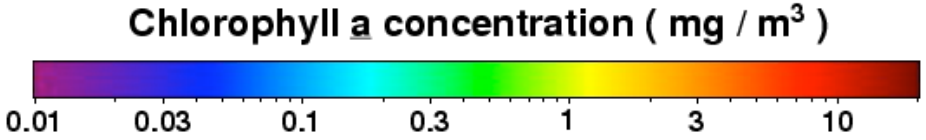


MODIS/Aqua



MODIS/Terra

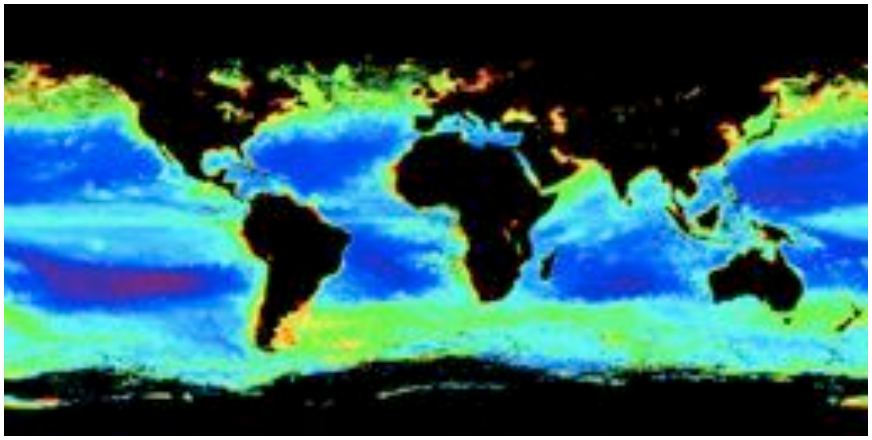




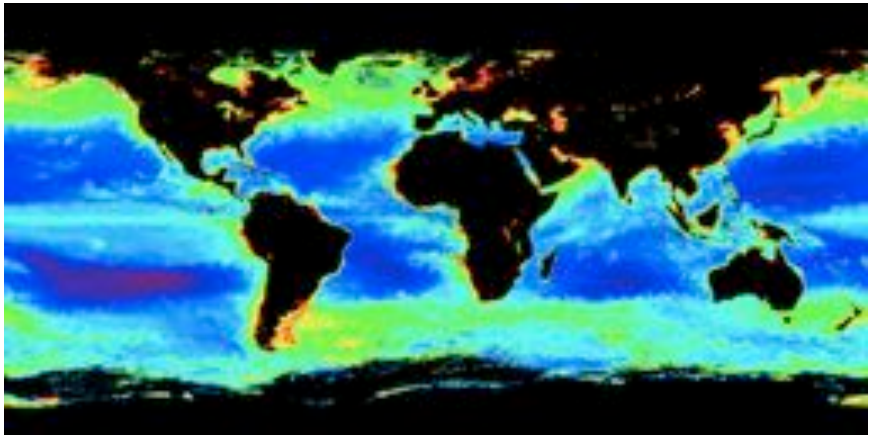
Chlorophyll spatial variation in good agreement

Fall 2008

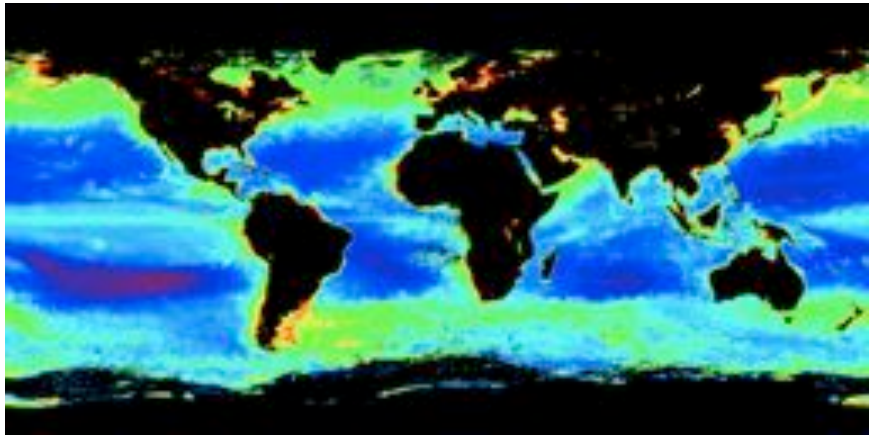
SeaWiFS

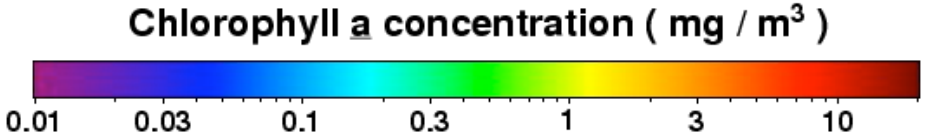


MODIS/Aqua



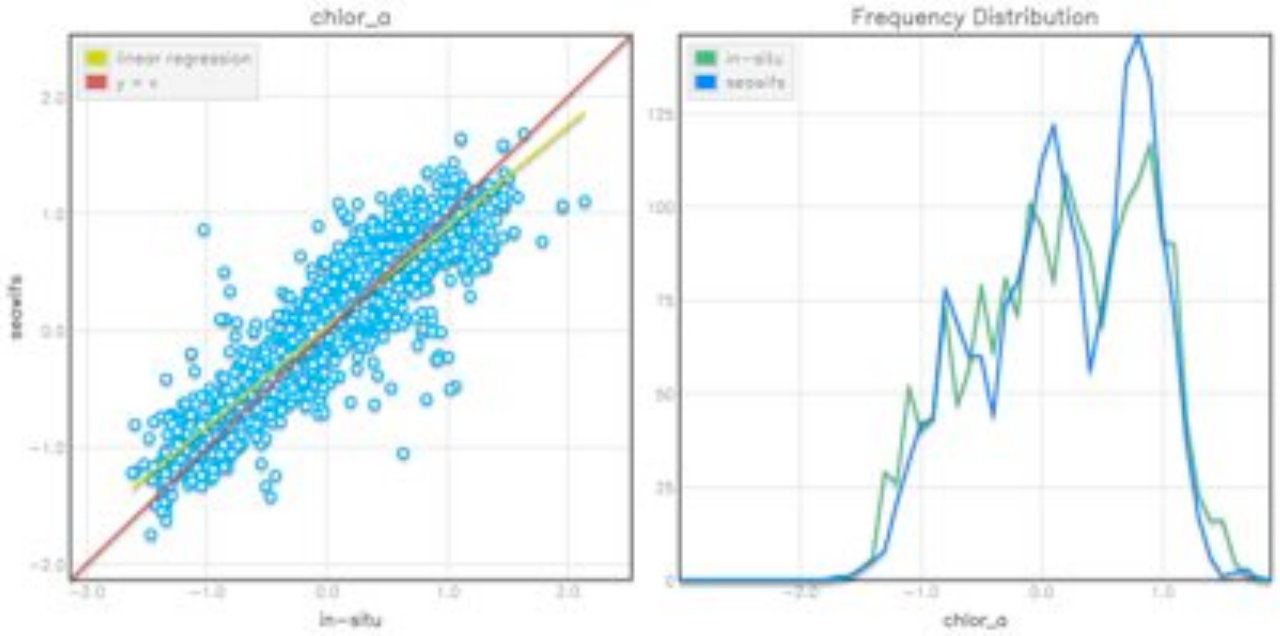
MODIS/Terra



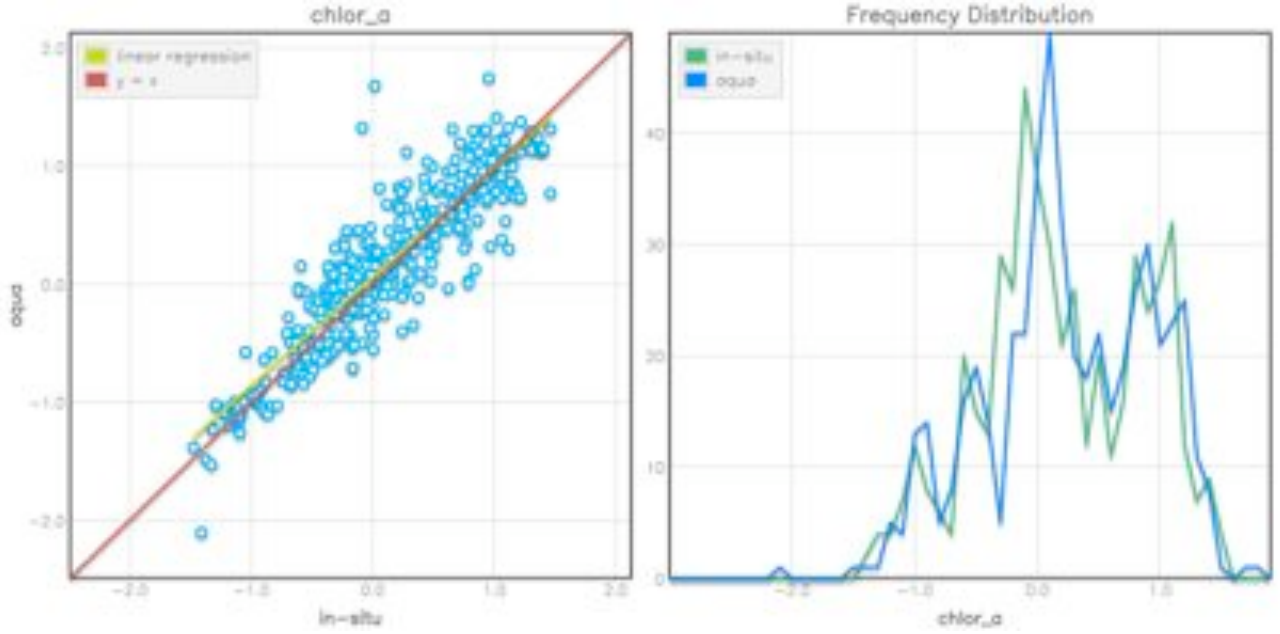


Chl_a in Good Agreement with Global In situ

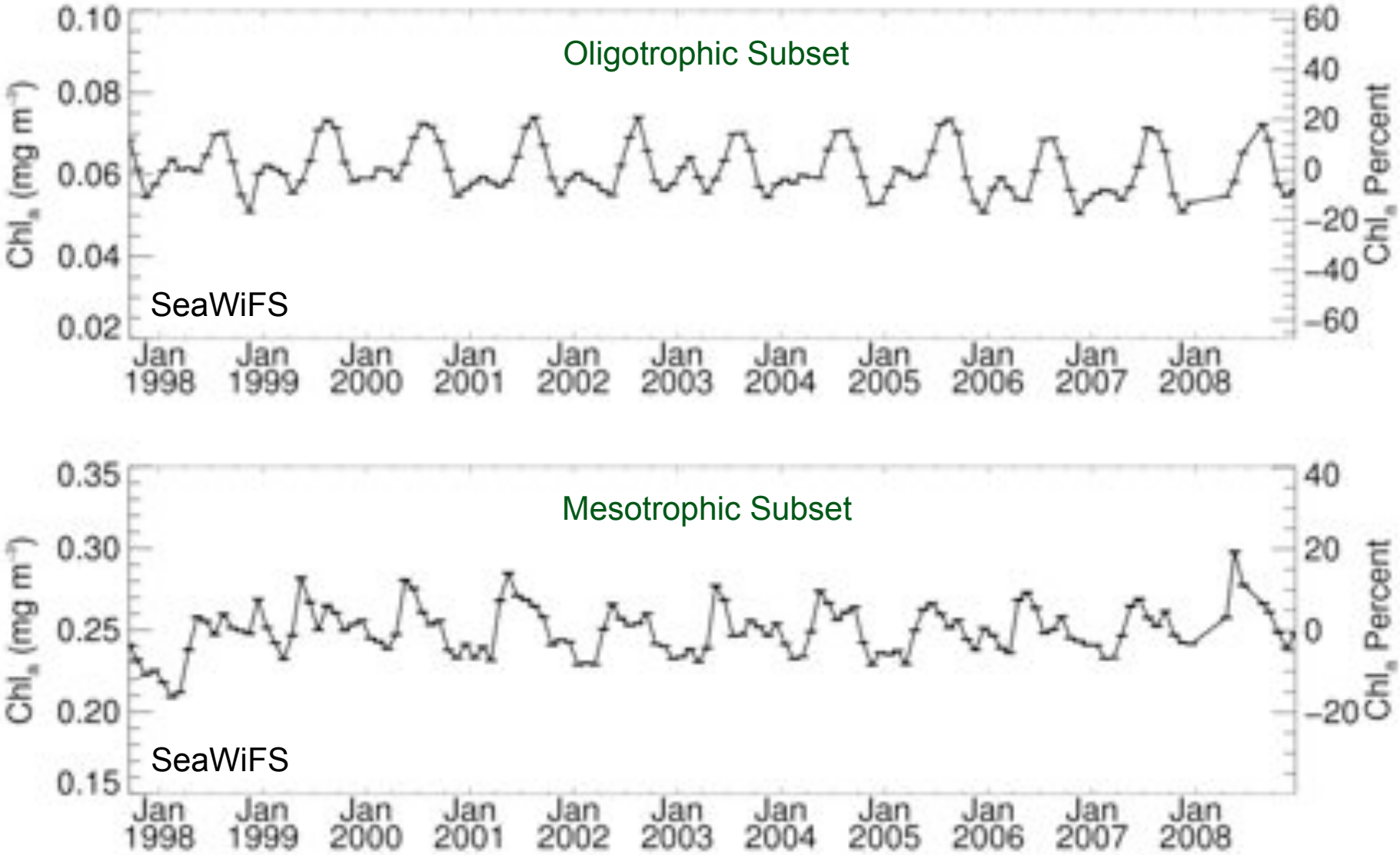
SeaWiFS
vs
in situ



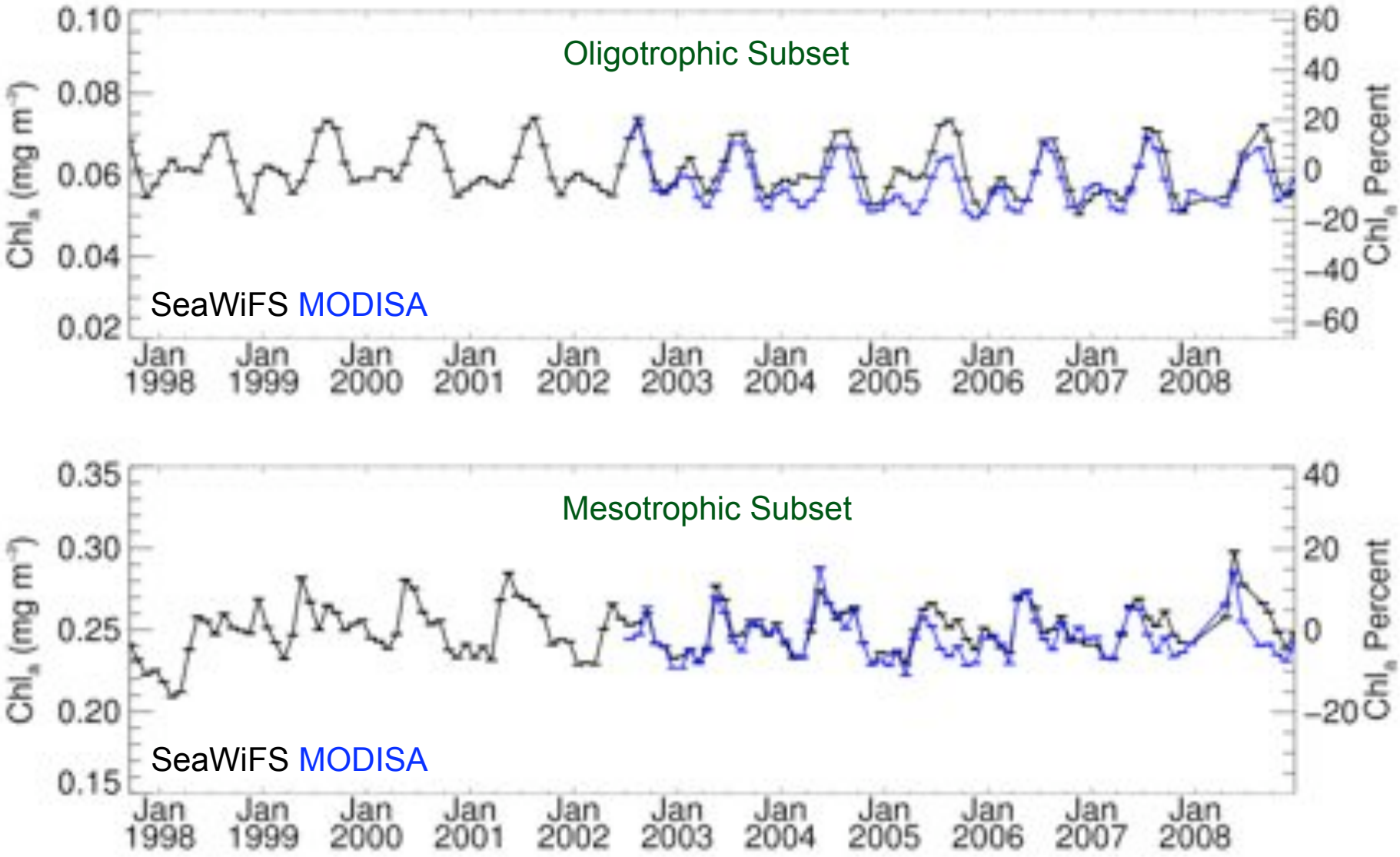
MODISA
vs
in situ



Global Chlorophyll Timeseries



Global Chlorophyll Timeseries



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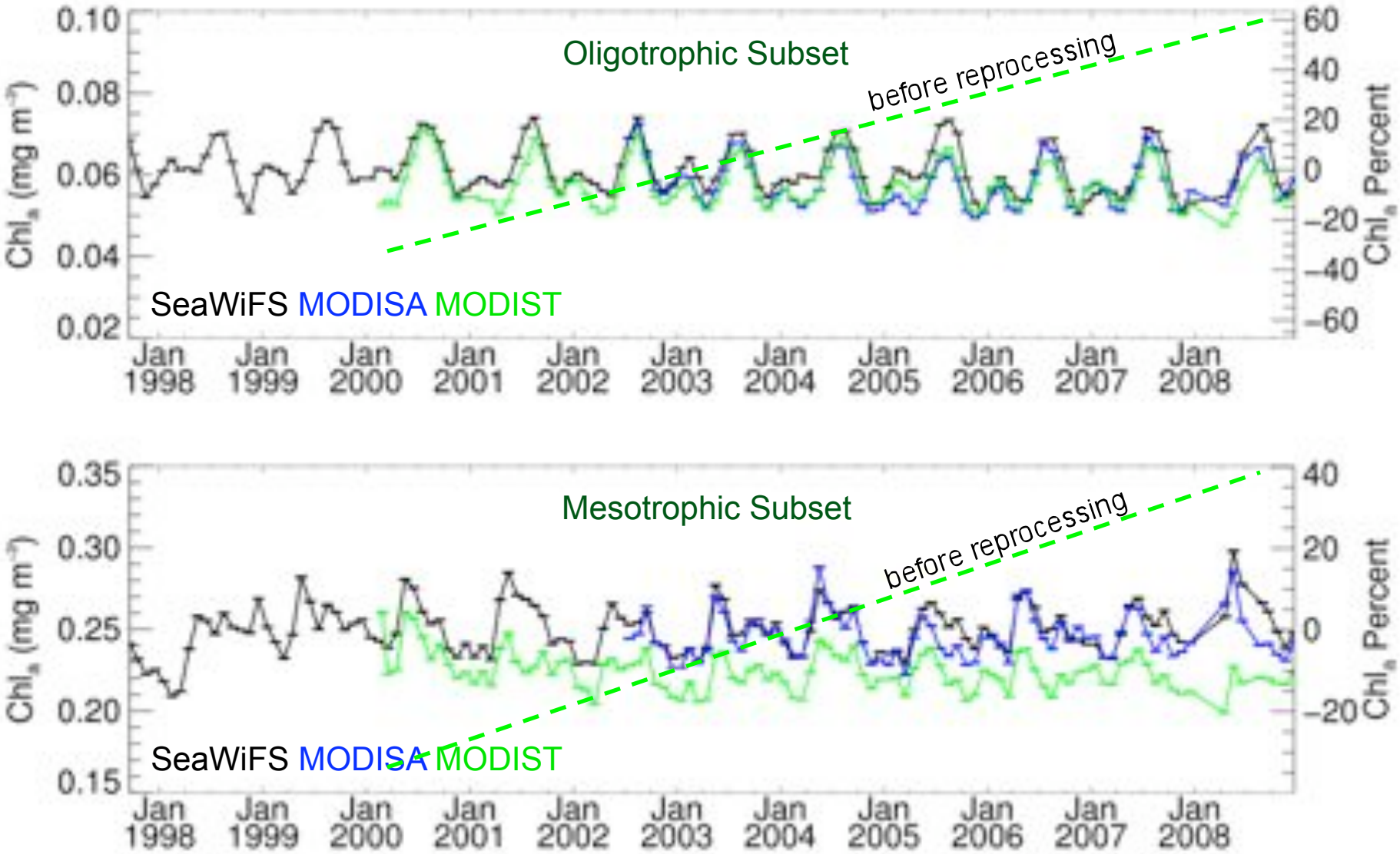
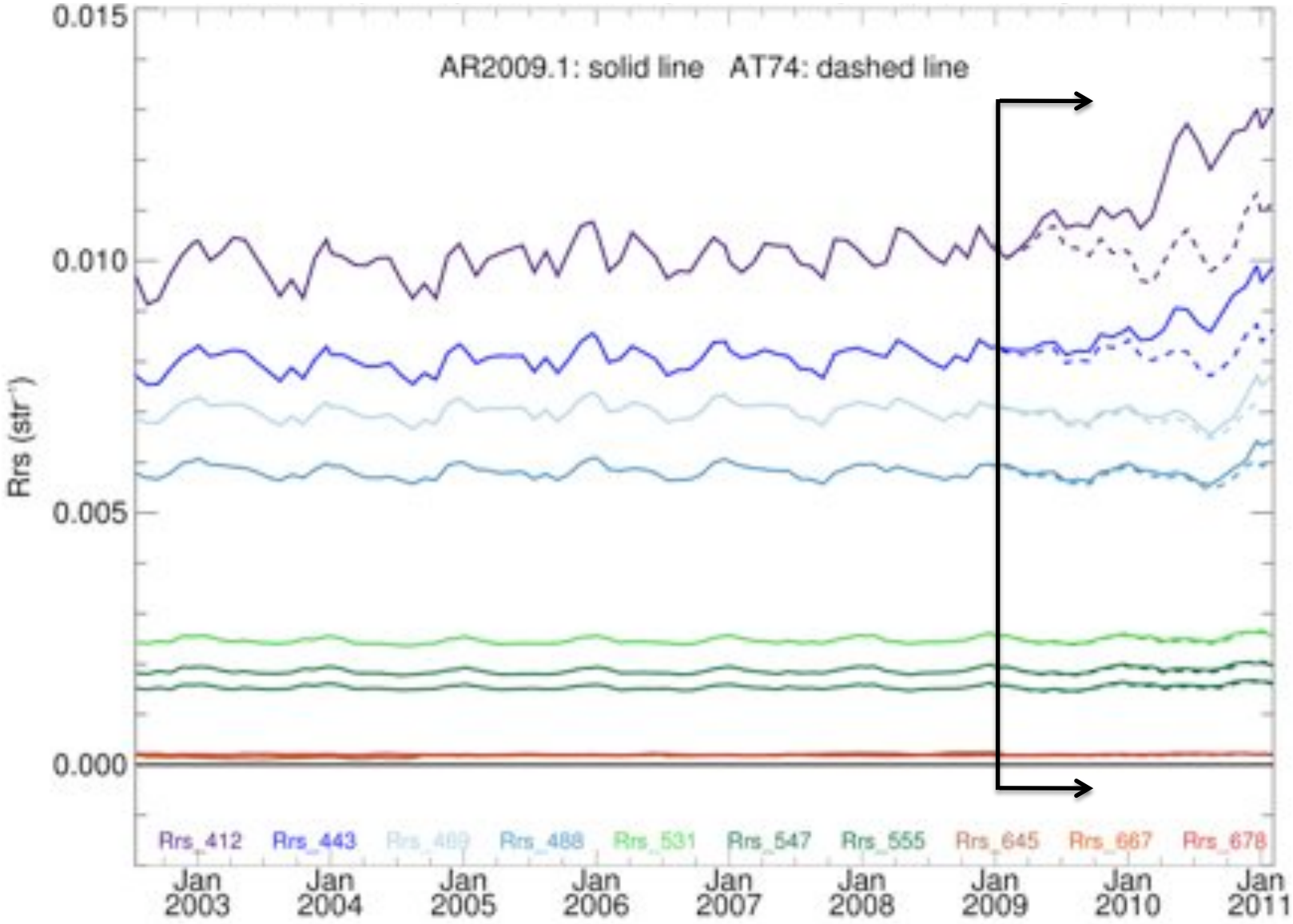


Coming Soon!
Late Mission Reprocessing of MODISA



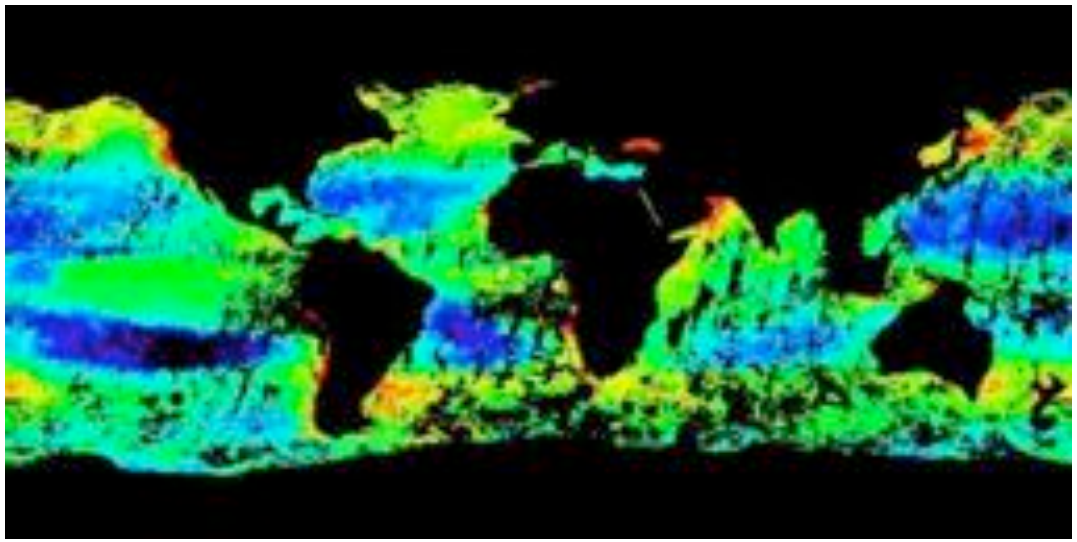
We will soon have the full MERIS Level-1B dataset

enabling reprocessing with NASA algorithms

- ESA-NASA bulk data exchange (lead Martha Maiden)
- All MERIS L1B for all of MODIS and SeaWiFS (L1A on media)
  - MERIS FR data by June
  - MERIS RR data by September
  - redistribution rights

MERIS
Chlorophyll
Oct. 2003

ESA 2006
Reprocessing



Summary

- SeaWiFS has provided the first decadal-scale climate data record for ocean chlorophyll and, by proxy, phytoplankton biomass.
- MODIS/Aqua open-ocean timeseries in very good agreement, suggesting the potential to extend the CDR into the future.
  - but biases remain that vary by bioregime (20% high in eutrophic waters)
  - revised calibration model / reprocessing needed to fix late mission trends
- MODIS/Terra in much better agreement with SeaWiFS & MODIS/Aqua, but after extensive recharacterization using SeaWiFS.
  - not an independent climate data record beyond seasonal scale
- MERIS needs reassesment after revised ESA calibration and reprocessing with common NASA algorithms.
- Common algorithms is an essential first step to multi-mission CDR.

characterization of instrument degradation is the primary challenge to development of ocean color climate data records

as it was for MODIS, so it will be for VIIRS ...


Thank You